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Food Access, Food Deserts, and the Women, Infants, and Children Program

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We examine the shopping behavior of Women, Infants, and Children (WIC) Program participants located in food deserts in the Greater Los Angeles area relative to peers in GLA located outside of food-desert boundaries. Results indicate that food-desert participants traveled slightly farther to shop than comparison participants. However, food-desert and non-food-desert participants were equally likely to visit multiple vendors and to visit a supermarket vendor. Food-desert participants did not pay more for program foods relative to comparison participants. On balance, the results indicate that WIC shopping behavior is very similar among food-desert and comparison participants.

Key words: food access; food cost; food desert; Women, Infants, and Children Program

Introduction

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Program provides access to food, health care, and nutritional education to low-income pregnant and postpartum women, infants, and children less than 5 years of age. The WIC Program is the third-largest food assistance program in the United States, as measured by expenditure, with FY2015 spending totaling $6.2 billion, 68% of which went to food costs. The program served 8.02 million people in FY2015 (U.S. Department of Agriculture, Food and Nutrition Service, Women, Infants and Children Program, 2016).

Cost containment is a fundamental problem for the WIC Program. Participants receive foods offered under the program at no charge and thus lack incentive to be price conscious in their purchase decisions. Accordingly, vendors have incentives to set high margins for WIC-eligible foods. Saitone, Sexton, and Volpe (2015) showed that program costs are significantly higher at small, convenience-type vendors when compared to supermarkets or supercenters. Thus, program costs could be reduced by either not authorizing those vendors or by imposing stringent price caps to restrain the prices charged for WIC foods, similar to the price caps in place for vendors who serve mainly or exclusively WIC participants—so called "above 50" or A50 vendors.[1]

However, restrictive price caps also have the potential to drive some small vendors from the program. WIC participants have low incomes (based on eligibility requirements) and often live in areas thought to have low food access, including areas designed by the U.S. Department of Agriculture as food deserts. Eliminating or discouraging small retailers from participating in the program could impede participant access to program benefits and discourage eligible participants from joining the program.

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[1] An additional concern with small WIC Program vendors is the quality of foods offered. Although vendors must meet minimum stocking requirements for program foods, these are often quite nominal. For example, WIC vendors in California are required to stock a minimum of $32 of fresh fruits and vegetables.

This paper addresses food-access issues for WIC Program participants using detailed administrative data from the California WIC Program, the nation's largest, with $726 million spent and 1.27 million participants in FY2015 (U.S. Department of Agriculture, Food and Nutrition Service, Women, Infants and Children Program, 2016). Our study focuses on the five-county area that comprises Greater Los Angeles (GLA),[2] home to nearly half of the state's WIC participants and nearly 7% of the nation's total WIC participants.

We seek to determine the extent to which WIC participants located in food-desert areas in GLA face program access issues compared to a comparison group of participants located in non-food-desert areas of GLA. Specifically, we focus on the extent to which food-desert participants (i) travel farther to shop (indicating a lack of nearby shopping opportunities), (ii) switch less frequently among program vendors (indicating a lack of shopping options), (iii) shop more often at high-cost convenience-type vendors (indicating lack of access to supermarkets or supercenters), and (iv) pay more for the staple foods that are part of WIC food bundles.[3]

Answers to these questions directly address the degree to which food-desert participants are constrained in their ability to shop, relative to their peers situated outside of food deserts, and, thus, the questions of whether (i) limiting the participation of high-cost small vendors in WIC could significantly impede participants' access to program benefits, and (ii) whether policy initiatives are needed to expand access to WIC benefits in food-desert areas.[4]

This paper also contributes to our understanding of shopping behavior and food access in regions designated as food deserts. Although this issue has been studied extensively in recent years, results have not been conclusive. Approaching this issue from the perspective of WIC Program shoppers has the potential to provide new insights because we are able to focus specifically on the behavior of a key population subgroup—low-income women who are pregnant or have small children—for whom food-access and food-cost concerns are likely to be most pronounced and of greatest policy concern.

Another advantage of our paper relative to prior work in contributing to understanding the grocery-shopping environment of food deserts is the large number of food-desert shoppers in GLA that we observe over time—over 78,000—and the large number of shopping transactions—over 7 million—in the dataset. Studies that rely on nationally representative panels such as the USDA's National Household Food Acquisition and Purchase Survey (FoodAPS) and Nielson's National Consumer Panel begin with a large numbers of participants, but there may be relatively few in critical subgroups, such as those in specific food-assistance programs and located in food-desert areas.[5]

The California WIC Program and Cost Containment

California has more than 200 active food instruments (FIs), which typically consist of bundles of food products designed to meet the dietary needs of infants, small children, and pregnant or

[2] GLA counties are Los Angeles, Ventura, San Bernardino, Riverside, and Orange.

[3] Although program foods are free to WIC participants, the prices charged by vendors for these foods can provide an excellent barometer of costs of staple foods for food-desert residents relative to others.

[4] Given our focus on the GLA area, a natural question is the extent to which our results generalize to other urban areas. In this regard, we note that the GLA urban area is similar to many other urban areas in the United States in terms of vehicle access and, thus, consumers' ability to use a vehicle for shopping purposes, a key consideration in terms of generalization of results. According to the U.S. Census Bureau's American Community Survey, 91% of Los Angeles residents have access to a vehicle, close to the 92% average for U.S. urban areas. Our results, however, may apply less directly in urban areas where vehicle access is notably lower, such as New York City, which—with only 68% of residents with vehicle access—has the lowest vehicle ownership in the United States.

[5] For example, FoodAPS is a weekly snapshot survey involving a nationally representative sample of 4,826 households (U.S. Department of Agriculture, Economic Research Service, 2016b), but only about 460 of those households participate in WIC; given that WIC benefits are issued and redeemed over the course of a month, only about a quarter of those households will have redeemed WIC benefits during the survey week.

postpartum women.[6] The most frequently redeemed infant food instruments are for formula. The majority of FIs for women and children contain a bundle of two to four foods, such as whole or low-fat milk, cheese, eggs, dried beans, peas, lentils or peanut butter, whole grains, breakfast cereal, and fruit juice.

WIC vendors in California are authorized on a store-by-store basis. Almost all supermarkets in the state participate in WIC, as do many small, convenience-type vendors and A50 vendors specializing in WIC-Program sales (in the sense that at least 50% of their food sales are through the WIC Program).

Based on the analysis of FI redemptions and in-store pricing for program vendors, Saitone, Sexton, and Volpe (2015) found large pricing disparities as a function of vendor size (measured by number of cash registers operated). Whereas stores operating at least six registers were found to achieve nearly all of the savings in redemption values associated with vendor size, small vendors as a group charged substantially higher prices on average and exhibited much more price dispersion than larger vendors.[7] For example, over the 29-month period from Oct. 2009–Feb. 2012 studied by Saitone, Sexton, and Volpe (2015), vendors with ten or more registers on average redeemed a food instrument containing low-fat milk, whole grains, and breakfast cereal for $14.27 (48.2%) less than one-register vendors and $10.57 less on average than two-register vendors. A50 vendors, by federal regulation, are constrained to charge no more than the statewide average redemption value for a food instrument and, thus, are essentially cost neutral to the program.

Hence, restraining the prices of smaller authorized vendors—specifically those in the 1–5 register groups—or limiting their program authorization presents itself as a potentially valuable cost-containment strategy for the WIC Program. Because the WIC Program is not an entitlement program and operates with a fixed budgetary appropriation, cost containment is important to its success. State agencies' ability to serve participants depends on effective cost containment.

However, a key concern with implementing this strategy and, indeed, the policy tradeoff is the issue of access for participants, especially those who live in food deserts. If these participants rely heavily on small vendors, then cost-containment efforts that limit small vendors' program participation could create important issues of access to program benefits. WIC Program participation among those eligible is relatively low, 62.7% in 2011 (Martinez-Schiferl, 2012; Johnson et al., 2014). As Figlio, Hamersma, and Roth (2015) emphasize, low participation in WIC is a significant concern, given evidence that participation improves food security (Kreider, Pepper, and Roy, 2016) and health outcomes (Bitler and Currie, 2005; Ludwig and Miller, 2005; Figlio, Hamersma, and Roth, 2009; Hoynes, Page, and Stevens, 2011; Colman et al., 2012; Rossin-Slater, 2013).[8] Addressing the access issue in food-desert areas and small vendors' role in facilitating program access are key goals of this paper.

Food Deserts

A food desert is a low-income area in which a substantial share of residents has limited access to a supermarket or large grocery store. Formally, a food desert can be defined in multiple ways.[9] The low-income criterion is generally based on the Treasury Department's New Markets Tax Credit Program, which for metropolitan-area tracts requires a poverty rate greater than 20% or a median family income of 80% or less of the metropolitan area's median family income. Low access is most

[6] The state also issues cash-value vouchers (CVVs) for the purchase of fruits and vegetables. Cost-containment concerns are mitigated for CVVs because they are issued in specific dollar amounts, much like SNAP vouchers, thereby incentivizing participants to shop for the best deals to enhance the purchasing power of the voucher.

[7] The high price dispersion within the small-vendor group is important because it suggests that higher prices charged by these vendors are not simply due to higher costs but rather that some vendors exploit the perverse economic incentives inherent to the program.

[8] Documented benefits include increased birth weight, improved maternal and infant health, and increased probability of breastfeeding.

[9] Bitler and Haider (2011) provide a critique of the concept and analyze the difficulties inherent to measuring food access.

commonly defined for metropolitan areas as at least 33% of a tract's population, or a minimum of 500 people, living more than 1 mile away from a supermarket or large grocery store; an alternative measure uses a 0.5-mile distance criterion.

Based on the joint income and food-access criteria, Dutko, Ver Ploeg, and Farrigan (2012) identified 4,175 urban census tracts (out of 50,784 total) as food deserts. An estimated 18.3 million people in the United States lived in these census tracts in 2010 (U.S. Department of Agriculture, Economic Research Service, 2016a). Based on analysis of the 2005–09 American Community Survey, Dutko, Ver Ploeg, and Farrigan (2012) show that food-desert populations have higher percentages of African Americans (31% vs. 14%) and Hispanics (20% vs. 15%), lower educational attainment (24% vs. 15% without high-school diploma), higher percentage in poverty (25% vs. 13%), and slightly higher percentage of households without vehicle access (11% vs. 9%) compared to urban census tracts.

Although the impacts of food deserts on food costs, nutrition, and health outcomes have been studied extensively in recent years, firm conclusions have remained elusive. Some studies (e.g., Hendrickson, Smith, and Eikenberry, 2006; Correll, 2010) emphasized the absence of quality, affordable food in food deserts as a key factor impeding low-income residents from maintaining healthy lifestyles. Morland, Diez Roux, and Wing (2006) found the local food environment, specifically the prevalence of supermarkets relative grocery and convenience stores, to be associated with reductions in obesity. Similarly, Chen et al. (2010) argued that food-access effects on BMI are spatially and income dependent, with low-income communities' health outcomes being more responsive to grocery access and the food environment.

However, other work has reached different conclusions. For example, Thomsen et al. (2016) found the food-desert effect on obesity of children to be small, although statistically significant. Cummins, Flint, and Matthews (2014) concluded that altering the food environment in a food-desert area by opening a new supermarket did not alter consumption habits and did not reduce obesity. Handbury, Rahkovsky, and Schnell (2015) found that, although healthy foods tend to be less available in low-income neighborhoods, spatial inequality in food access explained only a small portion of the observed variation in nutritional content of household purchases; education and food knowledge emerged as more important explanatory factors.

Given that, by definition, food access is limited in food-desert areas, a key consideration in understanding the health impacts of food deserts is the shopping behavior of residents living within these boundaries. Correll (2010) argued that food deserts can impose high and virtually insurmountable barriers between SNAP program benefits and healthy food choices because women would be forced to secure childcare, forgo wages, and either make use of time-consuming public transportation or procure other means of reaching supermarkets to get access to healthy foods.

However, Dutko, Ver Ploeg, and Farrigan (2012) found that 89% of residents in urban food deserts had vehicle access, and other work has shown that low-income residents are quite mobile in terms of food shopping. A study of SNAP participants in nine areas distributed across highly urban, small city, and rural regions by Mantovani and Welsh (1996) found that participants often did not patronize the nearest food store, preferring to travel instead to more affluent areas to shop or to specific market areas. Edin et al. (2013) confirmed this finding via in-depth interviews with SNAP participants that showed that many low-income shoppers eschew proximate, more expensive, retailers in favor of a larger and less expensive supermarket chain options that are farther away.

In a nationally representative survey of SNAP-eligible consumers, Ohls et al. (1999) found that among program participants the average distance to the nearest supermarket was 1.8 miles, but the average distance to the store used most often by participants and eligible nonparticipants was 4.9 miles. Cole (1997) found a similar result among SNAP participants in Maryland—the average distance to the nearest food store was 0.3 miles, but the average distance traveled to redeem benefits was 2.7 miles. Less has been done to study the behavior of WIC shoppers relative to SNAP shoppers, but small-scale study of WIC shoppers in Northern Philadelphia by Hillier et al. (2011) also showed participants often bypassed the nearest eligible vendor in favor of a more distant alternative—0.65

additional miles for non-WIC food shopping and 0.95 miles for WIC shopping. The average travel distance was 1.58 miles for non-WIC shopping and 1.07 miles for WIC shopping.[10]

Methodology and Data

We compare the shopping behavior of WIC participants in food deserts in GLA with that of a comparison group of WIC participants located in non-food-desert regions of GLA. While acknowledging the concerns expressed by Bitler and Haider (2011) and others about the economic definition of a food desert, this study used the standard definition, as indicated in the USDA's Food Access Research Atlas (U.S. Department of Agriculture, Economic Research Service, 2016a), using only the low-access criterion. All WIC participants have low incomes based on program eligibility, so access is the key consideration regardless of whether or not a WIC participant lives in a low-income census tract (based on the formal definition). Food deserts based solely on the urban (one mile) supermarket-access criterion include all areas defined by the intersection of the access and income criteria, as well as others.[11] A key contribution of this study is to evaluate whether there are significant differences in food access in GLA between food deserts and a comparison group of non-food-desert locations by analyzing WIC transactions.

The primary data source is California WIC administrative data that encompass each individual transaction made by participants in the treatment (i.e., food desert) and control/comparison groups. Each transaction indicates the food instrument purchased, the total dollar value of the transaction, participant identification number, vendor identification number, and the WIC clinic to which the WIC participant has been assigned.[12] We worked with an unbalanced panel of over seven million transactions in the treatment and comparison groups across the 24-month period from January 2010 through December 2011. The panel is unbalanced because WIC participants often do not remain in the program for a long period of time. Thus, participants enter and exit over the 24-month study period. By matching vendor identification with the database of WIC Program vendors maintained by the CA WIC Agency, we obtained the street address of each vendor and, thus, the exact location of each food transaction.

The WIC clinic identification information plays an important role in the analysis because each participant is assigned to a particular clinic where she must go periodically to obtain her allocation of FIs and receive other program services. The location of the assigned clinic is used as a proxy for the participant's home location, obviating the limitation in the data that personal information on individual participants, including home address, is strictly confidential and unavailable to researchers. California WIC operated ninety-eight clinics in the GLA region during the study period. Clinics are located strategically in areas with high numbers of WIC participants, and participants are assigned to a clinic in close proximity to their residence (e.g., program rules require participants to live within the service area of their assigned clinic), making the clinic location a good proxy for the participant's home location, especially in highly urbanized areas such as GLA.

Demographic information at the participant level is also unavailable due to confidentiality, so we relied instead on demographic data for the clinic's census tract from the 2009 and 2010 American Community Surveys. These demographic data were joined with the program redemption data.

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[10] All distance measurements in the indicated studies are relative to a shopper's home location, ignoring the fact that it may be more convenient to shop for food from a work, school, or other frequently visited location.

[11] A visual comparison of the definitions of access only versus access plus income is available at the USDA's food-desert locator (https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/). Choose Los Angeles from the location menu and select from among the available defining criteria.

[12] Except for identification number, clinic assignment, and food purchase information, all other participant information is unavailable due to strict confidentiality requirements maintained by the California WIC Agency.

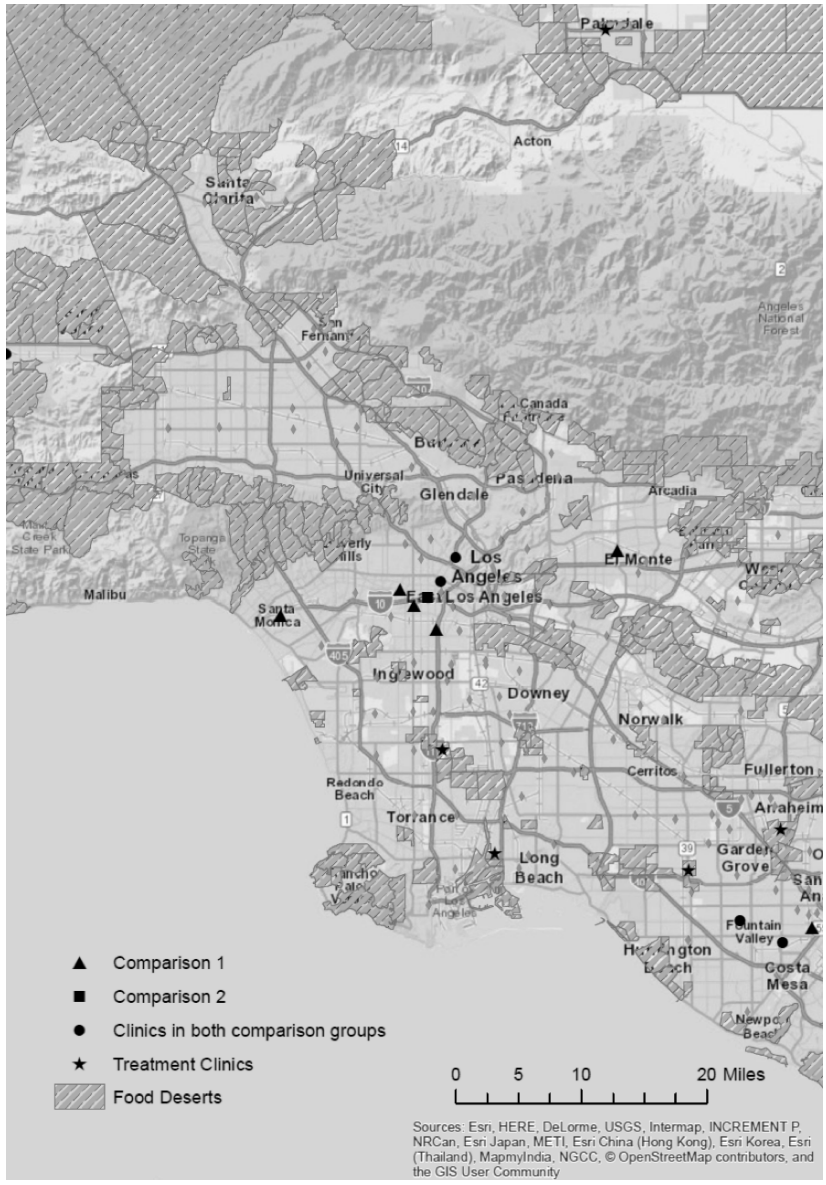

Figure 1. Food Deserts and Treatment and Comparison WIC Clinics in GLA

Constructing Treatment and Comparison Groups

A participant was considered part of the food-desert treatment group if she was assigned to a clinic located in a food desert and as a non-food-desert participant if her assigned clinic was located outside of a food-desert area, defined using the USDA low urban access criterion. Eight GLA clinics were assigned to the food-desert treatment group on this basis. Two of these clinics were omitted due to the absence of demographic data associated with their census tracts, and another was eliminated because it opened during the study period and had relatively few food instrument redemptions during the study period, leaving five treatment clinics in total.

In principle, any WIC clinic in the GLA region located outside the boundaries of a food desert could be considered part of the control or comparison group. However, because the location of a clinic is only a proxy for participant home address, a concern associated with choosing clinics

Table 1. Demographic Variables for Treatment and Comparison Groups

Variable	Group	Mean	Std. Dev.	Min	Max
Population under age 5, percentage of total population	Comparison 1	7.3	2.7	3.9	13.3
	Comparison 2	10.0	1.8	6.9	12.1
	Treatment	5.1	3.8	0.0	10.6
School-age population, ages 5–17, percentage of total population	Comparison 1	20.7	5.1	11.9	31.6
	Comparison 2	17.6	5.1	8.3	26.0
	Treatment	23.2	7.2	16.3	33.2
African-American population, percentage of total population	Comparison 1	6.7	9.4	0.0	26.2
	Comparison 2	2.3	2.1	0.1	6.1
	Treatment	14.5	14.4	1.1	31.5
Asian population, percentage of total population	Comparison 1	13.9	14.5	1.5	53.9
	Comparison 2	0.6	0.4	0.0	1.2
	Treatment	16.2	10.5	2.1	30.5
Hispanic population, percentage of total population	Comparison 1	55.3	24.9	13.3	91.8
	Comparison 2	61.5	22.5	22.4	96.0
	Treatment	41.6	19.2	19.9	69.3
Median household income ($)	Comparison 1	46,540	15,098	23,266	63,317
	Comparison 2	44,769	14,346	21,976	68,814
	Treatment	46,765	22,071	11,750	67,833
Percentage of population in poverty	Comparison 1	20.3	12.1	7.0	46.2
	Comparison 2	19.9	10.6	6.7	42.6
	Treatment	22.4	29.3	0.0	71.4

located close to a food desert for the comparison group is that a WIC participant who lives in a food desert may be assigned to a clinic that is located outside the food desert but close to its boundary. It would be a mistake to assign such a person to the comparison group.

In order to guard against this possible contamination of the comparison group, clinics located close to food-desert boundaries were not assigned to the comparison group. On the other hand, to help ensure that comparison participants were broadly comparable to treatment participants, apart from food-desert status, clinics located far away from food-desert areas were also not desirable for the comparison group. Thus, a range of 3–15 miles from the boundary of any food desert was chosen as the initial basis to select candidate comparison clinics, resulting in twenty-three WIC clinics emerging as candidates for the comparison group.[13]

To test for robustness of results to choice of comparison group, two distinct approaches were used to select comparison clinics from the available set of twenty-three. Comparison 1 was selected to provide matched comparison clinics to the extent possible. Hierarchical cluster analysis was used for this purpose, with the clustering criteria being key socioeconomic and demographic characteristics of the population in the clinic's census tract, including percentage under the age of five (the age cutoff for WIC eligibility), percentage school-age children, percentage African American, percentage Asian, percentage Hispanic, percentage in poverty, and median household income. Thirteen comparison clinics were chosen based on their match to the treatment clinics according to these criteria.[14]

Second, to achieve maximum protection from assigning FI redemptions by residents of food deserts into the comparison group, Comparison 2 selected the eleven clinics that were located

[13] Given that food deserts are scattered across the GLA region (figure 1), the requirement that a clinic be at least 3 miles away from *any* food desert excluded many clinics from consideration.

[14] Hierarchical cluster analysis was performed using the popular Ward's linkage as the clustering criterion. At least one match was selected for each treatment clinic. Multiple matches were used for some treatment clinics if the clustering criterion indicated multiple close matches. Details on the hierarchical cluster analysis are available from the authors on request.

Table 2. Food Instrument Redemptions by Year and Participant Category

	Comparison 1			Treatment		
Category	**2010**	**2011**	**Share %**	**2010**	**2011**	**Share %**
B	192,829	191,997	7.70	74,241	74,167	6.22
C	1,579,214	1,631,049	64.19	760,524	796,388	65.30
I	338,062	309,739	12.95	174,556	156,016	13.86
N	111,117	108,692	4.40	62,014	59,642	5.10
P	269,726	268,532	10.76	112,441	114,359	9.51
Total	**2,490,948**	**2,510,009**	**100.00**	**1,183,776**	**1,200,572**	**100.00**

Notes: B = breastfeeding mother, C = child 13 months to 5 years of age, I = infant (birth to 12 months of age), N = postpartum mother, and P = pregnant woman.

farthest from any food desert among the twenty-three candidates. All eleven were at least 4 miles from any food desert defined by the low-access criterion. One of these clinics had no demographic data associated with its census tract and was eliminated, leaving ten clinics in Comparison 2. Six clinics were in both comparison groups.

The treatment and Comparison 1 and 2 clinics are shown in figure 1. The regions indicated with darker shading and diagonal lines represent food-desert areas based on the USDA low-food-access criterion. Stars represent the locations of food-desert treatment clinics, circles represent those clinics that meet the criteria for inclusion in both comparison groups, triangles represent the locations of clinics in Comparison 1 only, and squares represent the locations of clinics in Comparison 2 only. Locations of clinics not included in the analysis are indicated with diamonds. Other excluded clinics located more than 15 miles from food-desert boundaries are not depicted due to the map's magnification.

Summary statistics of the demographic variables for the clinics in the food-desert treatment group and Comparison Groups 1 and 2 are contained in table 1. Both groups compare closely to the treatment group based on median household income and percentage of population in poverty. Comparison 1 clinics are more similar to the treatment clinics in terms of ethnic composition and population shares under the age of five and school age than Comparison 2. Comparison 1 was thus chosen for the analysis contained in this paper. All analysis was replicated for Comparison 2, and those results are available from the authors. We also include a brief discussion of results for Comparison 2 as a robustness check on the main results.

The treatment group consisted of 78,465 WIC participants assigned to one of the five food-desert treatment clinics. Comparison 1 consisted of 146,964 WIC participants assigned to one its thirteen clinics.[15] Table 2 shows the number and share of FIs (observations) redeemed by year and participant category for treatment and comparison groups. WIC participants are assigned to one of five categories: (i) breastfeeding mother, B; (ii) child 13 months to 5 years of age, C; (iii) infant (birth to 12 months of age), I; (iv) postpartum mother, N; and (v) pregnant woman, P. Child status has the highest share of FIs redeemed across all clinics (nearly 65%), followed by the infant and pregnant woman categories. The postpartum woman category has the lowest proportion of FIs redeemed. This breakdown is consistent between the treatment and comparison groups. The treatment and comparison groups are similar in participant shares in the different categories.

[15] About 1.8% of food instrument redemptions were dropped from the analysis because the travel distance from clinic to redeeming vendor exceeded 25 miles. Any redemption with travel distance greater than 25 miles was considered to be idiosyncratic (e.g., due to participants traveling on vacation or business) and was deleted to avoid skewing results, particularly pertaining to average travel distances.

Table 3. Food Instrument Redemption Patterns by Vendor Types and Locations

	Location of Vendor Where Food Instrument Is Redeemed										
	Comparison 1 (Not in Food Desert)										
	Same as Clinic			Different/FD			Different/Not FD			Total	
Registers	Number of FIs	Column Percent	Row Percent	Number of FIs	Column Percent	Row Percent	Number of FIs	Column Percent	Row Percent	Number of FIs	Column Percent
Above–50 Store	840,436	79.1	41.6	1,472	7.0	0.1	1,177,510	30.06	58.3	2,019,418	40.4
1–2	76,095	7.2	26.5	458	2.2	0.2	210,569	5.4	73.3	287,122	5.7
3–4	14,880	1.4	8.1	401	1.9	0.2	168,007	4.3	91.7	183,288	3.7
5–6	56,399	5.3	18.2	27	0.1	0.0	241,410	6.2	81.1	297,836	6.0
7–9	32,790	3.1	4.6	6,174	29.2	0.9	675,342	17.2	94.5	714,306	14.3
10+	41,846	3.9	2.8	12,589	59.6	0.8	1,444,552	36.9	96.4	1,498,987	30.0
Total	1,062,446	100	**21.2**	21,121	100.0	**0.4**	3,917,390	100.0	**78.3**	5,000,957	100.0

	Location of Vendor Where Food Instrument Is Redeemed										
	Treatment (in Food Desert)										
	Same as Clinic			Different/FD			Different/Not FD			Total	
Registers	Number of FIs	Column Percent	Row Percent	Number of FIs	Column Percent	Row Percent	Number of FIs	Column Percent	Row Percent	Number of FIs	Column Percent
Above–50 Store	896,977	42.8	88.1	69,227	88.4	6.8	51,977	24.7	5.1	1,018,181	42.7
1–2	116,582	5.6	86.5	9,128	11.6	6.8	9,010	4.3	6.7	134,720	5.7
3–4	48,266	2.3	84.8	0	0.0	0.0	8,681	4.1	15.2	56,947	2.4
5–6	116,418	5.6	100.0	0	0.0	0.0	0	0.0	0.0	116,418	4.9
7–9	244,409	11.7	82.2	0	0.0	0.0	52,920	25.1	17.8	297,329	12.5
10+	672,858	32.1	88.4	0	0.0	0.0	87,895	41.8	11.6	760,753	31.9
Total	2,095,510	100.0	**87.9**	78,355	100.0	**3.3**	210,483	100.0	**8.8**	2,384,348	100.0

Table 4. Travel Distance Summary by Participant

	Treatment					Comparison 1				
<1 mile	6,830				8.70%	38,173				25.97%
≥ 1 mile	71,635				91.30%	108,791				74.03%
	Obs.	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
	78,465	3.59	2.66	0.0004	24.95	146,964	3.20	3.83	0.009	25.00

Analysis

Table 3 summarizes the location and type of vendor visited by the treatment and comparison participants. Three scenarios were considered for the comparison group: a participant (i) redeems the food instrument at a vendor located in the same census tract as her clinic location, or she redeems the FI outside the tract where her assigned clinic is located at (ii) a vendor in a food-desert tract or (iii) a vendor in a non-food-desert tract. Comparison participants redeemed only 21.2% of their FIs in their clinic tract area. Another 78.3% were redeemed in non-food-desert tracts outside the clinic area, and only 0.4% of FIs were redeemed in food-desert areas. Thus, more than three-quarters of comparison participants traveled outside of their clinic census tract to shop. About 44% of comparison participants' FIs were redeemed at vendors operating seven or more registers.

For the treatment group, three redemption scenarios were identified: A food-desert participant: (i) travels to a non-food-desert tract to redeem the FI, (ii) shops at a vendor located in the same food-desert tract as her assigned clinic, or (iii) travels to another food-desert tract to redeem her FI. Nearly 88% of treatment participants' FIs were redeemed outside of a food desert, which indicates that treatment participants did have low food access in the vicinity of their clinic, but had the ability, on average, to travel to redeem their WIC benefits. Only 3.3% of FIs were redeemed in the same food-desert area as the clinic where the FIs were issued, and 8.8% were redeemed in a different food-desert tract than the one where the clinic was located. FIs redeemed in the clinic's tract were transacted exclusively at vendors with one or two registers or at A50 vendors, while those redeemed in food-desert tracts outside the clinic location involved a broader mix of vendors.[16]

Table 3 segments vendors according to the vendor peer groups designated by the California WIC Agency in terms of number of checkout registers operated: 1–2, 3–4, 5–6, 7–9, and 10+. A50 vendors comprise their own peer group regardless of the number of registers. About 87% of FIs for food-desert participants were redeemed at A50 vendors and vendors with seven or more registers. Food-desert and comparison-group participants were equally likely to redeem their FIs at vendors with seven or more registers—about 44% in each case. Only 8.1% of food-desert participants' FIs were redeemed at 1–4 register vendors, which some have argued provide crucial access for food-desert participants, slightly less than the 9.4% of FIs redeemed at these vendors by comparison participants.

The shopping distance of a participant was defined as the straight-line distance between her assigned clinic and the vendor(s) where she shops. Table 4 compares travel distances for food-desert and comparison participants.

Treatment participants traveled on average 3.59 miles to shop for WIC products, and 91.3% traveled at least one mile. Comparison-group participants traveled 3.20 miles on average and about 74% of them traveled more than one mile. These travel distances can be compared with walking distances of 500 meters (≈ 0.31 miles) (Wrigley, Warm, and Margetts, 2003) to 1 mile (Ver Ploeg et al., 2009) that have been used as the estimated breakpoint between high and low access in urban areas. In general, results show that most WIC participants' access is not limited by walking distance

[16] Some food instruments redeemed in food-desert areas involved 7–9 and 10+ register vendors (table 3). A census tract may contain a large vendor and still be classified as a food desert if a large enough share of the tract's population lives more than 1 mile from the vendor.

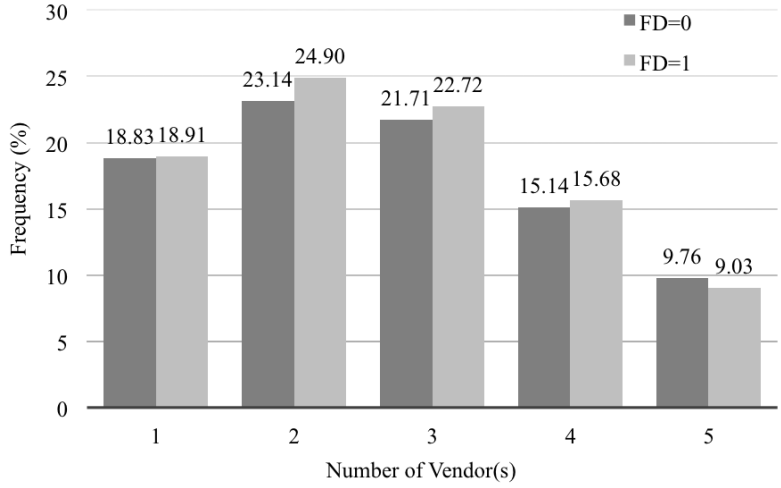

Figure 2. Number of Vendors Visited by Treatment and Comparison Participants

Notes: 11.42% (8.76%) of comparison (treatment) participants redeemed FIs at more than five vendors.

in GLA. These distances are roughly comparable to those found by Cole (1997) and Ohls et al. (1999) for SNAP participants' travel to redeem benefits but considerably farther than the travel distances reported by Hillier et al. (2011) for WIC shoppers in Philadelphia.

Food-desert and comparison-group participants were equally likely to visit multiple vendors during the 6-month period from January 2010 through June 2010 (figure 2).[17] Nearly 80% of participants in both groups redeemed benefits at multiple vendors, indicating the presence of vendor choices for the vast majority. The modal number of vendors visited by each group was two, followed closely by three and then one. About 25% (23%) of food-desert participants visited two (three) vendors. On balance, figure 2 shows that there is little difference between the treatment and comparison groups for this measure of participant access.

In what follows we define small vendors as those operating 1–5 registers. This is consistent with the Saitone, Sexton, and Volpe (2015) finding that program cost containment issues primarily pertain to 1–5 register vendors. Given this designation, 6,354 food-desert participants patronized small vendors during the 6-month window. However, among this group 964 also patronized one or more A50 vendors, 2,351 also visited one or more large (6+ registers) vendors, and 1,978 redeemed FIs at both A50 and large vendors during the 6-month window; only 1,061 food-desert participants (1.35%) shopped exclusively at small vendors during this period.

Table 5 addresses the question of food costs for participants assigned to food-desert clinics versus comparison clinics for the three most popular combination FIs, which collectively accounted for over 31% of WIC Program food expenditures in California during the study period, and for the Enfamil formula concentrate FI, which had the largest sales share among formula FIs.[18] A50 vendors, as noted, are constrained to charge no more than the statewide average price for each FI they sell, and most A50 vendors charge prices close to this price ceiling. Thus, there is little difference in the A50 prices between treatment and comparison groups. Although prices charged by both small and large vendors were generally not constrained by program-imposed price ceilings during this time period, we see little difference across these major FIs in the prices paid by food-desert versus comparison participants at either small or large vendors.

[17] We focused on this sub-interval of the full two-year sample period for this portion of the analysis to limit potential distortions from participants joining and exiting the program.

[18] WIC agencies engage in an exclusive selling arrangement with a formula manufacturer in exchange for receiving a manufacturer rebate. Enfamil is the exclusive formula seller in California.

Table 5. Comparative Food Cost by Food-Desert and Comparison Groups by Food Instrument and Vendor Size

	Redemption Value ($) Food-Desert Participants				Redemption Value ($) Non-Food-Desert Participants			
Food Instrument	**A50**	**Small**	**Large**	**FI-Wtd Avg.**	**A50**	**Small**	**Large**	**FI-Wtd Avg.**
6003 (Low-fat milk, whole grains, breakfast cereal)	16.25	22.42	14.99	16.31	16.27	22.66	15.13	16.59
6011 (Low-fat milk, whole grains, 128 oz. juice)	14.16	20.02	12.76	14.15	14.15	20.12	12.85	14.36
6012 (Low-fat milk, eggs, cheese, peanut butter/dry beans)	14.40	18.80	13.94	14.60	14.33	18.70	14.03	14.74
1011 (4 cans of Enfamil formula concentrate, 13 oz.)	70.87	99.00	64.37	70.62	69.79	100.86	63.53	71.02

Notes: Small vendors are defined as those operating 1–5 registers and large vendors as those operating 6+ registers.

Prices paid by food-desert participants are nearly identical to those paid by comparison-group participants for each FI and for each vendor type. However, to the extent the prices paid differ, food-desert participants usually paid slightly less than those in the comparison group. Across all FIs sold in the 24-month sample period (not just those in table 5), average FI redemption value was $18.49 in the food-desert treatment group and $18.73 in the comparison group, a difference of 1.3%. Thus, although they may travel slightly farther to shop than consumers located in non-food-desert regions, the evidence indicates that food-desert shoppers do not pay more, at least for the staple foods that comprise WIC Program FIs.[19]

A different but related question is whether participants who actually redeem FIs in a food desert pay more than the average redemption cost in non-food-desert census tracts. The answer is no. Although only 4.35% of WIC transactions by treatment and comparison participants during the study period were made in food-desert tracts, the average redemption value for each of the four major FIs listed in table 5 was slightly less in food deserts: FI 6003 ($16.31 vs. $16.59), FI 6011 ($14.15 vs. $14.36), FI 6012 ($14.60 vs. $14.74), and FI 1011 ($70.62 vs. $71.02).[20]

Econometric Analysis of Travel Distances

Although the summary data indicate that food-desert participants traveled on average 0.39 miles farther to shop than their comparison-group counterparts, this statistic fails to control for other factors apart from food-desert status that could impact travel distance. We constructed an econometric model to better understand the determinants of participants' WIC shopping travel distance. In addition to a food-desert indicator variable, other explanatory variables included:

- Participant's program status (from table 2): pregnant woman, postpartum mother, breastfeeding mother, or woman with an infant or with young children. Program status gives some insight into individual participants' living situation and, potentially, their mobility.[21]

[19] Table 5 also illustrates the Saitone, Sexton, and Volpe (2015) finding regarding the high prices charged by 1–5 register vendors to redeem food instruments relative to either A50 vendors or vendors operating 6+ registers.

[20] We have no way to control for possibly heterogeneous product qualities purchased in this comparison or in the comparison of prices paid by treatment versus comparison participants. It is possible, for example, that comparison participants have access to a higher-quality and, hence, costlier products than treatment participants. This possibility is mitigated somewhat by the relatively homogeneous products contained in the four food instruments (table 5).

[21] Although each food instrument redeemed is associated with a specific participant status, a given household may have multiple family members participating in the WIC Program. For example, a parent may redeem food instruments for an infant or child and also for herself on a particular shopping trip.

- An indicator variable for cash-value vouchers (CVVs) to denote the purchase of fruits and vegetables under the hypothesis that participants may travel farther to shop for fruits and vegetables relative to food instruments containing standardized packaged goods.
- Census tract demographic variables (from table 1).

The regression model comprised of these variables represents model 1. A second model, model 2, was created by adding vendor-type indicator variables to model 1 based on the hypothesis that participants may travel farther to visit certain vendor types. Vendors were classified as A50 (the default category), small (1–5 registers), or large (6+ registers).[22]

The natural log of distance traveled for each transaction was regressed on the aforementioned variables for models 1 and 2.[23] Since data are at the transaction level, the redemption records could be correlated across FIs for the same participant. Therefore, standard errors were clustered on participant ID to control for within-participant correlation.

Estimation results for the 24-month sample are presented in table 6. The food-desert indicator variable is positive and highly significant in both models, indicating that food-desert participants traveled on average 9.4% (model 1) to 15.4% (model 2) farther to redeem FIs than participants in the comparison group, *ceteris paribus*. Evaluated at the mean travel distance for the comparison group, these percentages indicate that food-desert participants traveled from 0.30–0.49 miles farther on average to shop than comparison participants—a range that encompasses the 0.39-mile difference based on the simple averages from table 4.

There is a sign reversal between models 1 and 2 for the coefficient on the CVV indicator, so there is no conclusive evidence that participants travel farther to shop for fruits and vegetables when redeeming WIC benefits. Coefficients on the indicator variables to denote participants' program status are small in absolute value and not always statistically significant. An exception is for postpartum women, who travel 5.5% (model 1) or 3.4% (model 2) farther to shop, on average, relative to the default category (children). This result may reflect that, among women and their children who are eligible for WIC, mobility is likely highest in the immediate months following a child's birth.[24]

Most of the census tract demographic variables are also statistically significant, but the effects are generally small. Median household income is, however, associated with longer travel distances, most likely reflecting wealthier households' greater access to transportation options. Each additional $1,000 in income is associated with 1.3% (model 1) to 1.5% (model 2) additional travel distance. Each additional percentage point of African-American population in a census tract is associated with 0.4% (model 1) to 1.1% (model 2) additional travel distance. Conversely, census tracts with higher percentages of Hispanic population involve less travel on average to shop for WIC products, with each additional percentage point of Hispanic population being associated with a 1.9% (model 2) to 2.7% (model 2) reduction in travel distance.[25]

The vendor-type indicator variables contained in model 2 are both economically and statistically significant. Other factors constant, participants travel on average 57.9% farther to visit a small vendor compared to an A50 vendor and 101% farther to visit a large vendor. This result confirms the perception that A50 vendors locate strategically to be in close proximity to program participants, either near locations of WIC clinics or areas where WIC participant density is high. Notably, the travel distance to visit small vendors compares more closely to the distance for large vendors than

[22] Indicator variables for season, year (2010 vs. 2011), and the dollar value of the redemption were also included in each model as control variables. Reporting of these results is omitted for brevity.

[23] The semi-log specification was chosen because the distribution of travel distances in the levels is highly right skewed but is approximately normal in the natural log. Goodness of fit as measured by R^2 was also substantially higher for the semi-log model compared to a model that was linear in the data levels.

[24] Postpartum status is available in the WIC Program for up to 6 months following birth.

[25] This likely reflects the presence of neighborhood grocers that locate in areas with high percentages of Hispanic residents (e.g., Ver Ploeg et al., 2009). Although these grocers tend to specialize in ethnic foods, many have chosen to be WIC vendors as well.

Table 6. Natural Log of Miles Traveled to Shop: Estimation Results

Variables	Model 1	Model 2
Food desert	0.094***	0.154***
	(0.010)	(0.010)
Cash-value voucher	0.042***	−0.063***
	(0.001)	(0.001)
Small vendor (1–5 registers)		0.579***
		(0.010)
Large vendor (6+ registers)		1.011***
		(0.006)
Infant (birth to 12 months)	−0.055***	−0.023***
	(0.007)	(0.006)
Breastfeeding mother	0.030**	−0.028**
	(0.010)	(0.009)
Pregnant woman	0.033***	−0.002
	(0.008)	(0.007)
Postpartum mother	0.055***	0.034***
	(0.008)	(0.008)
% Population under age 5	0.104***	0.093***
	(0.002)	(0.002)
% Population school age (ages 5–17)	0.068***	0.059***
	(0.001)	(0.001)
% Asian population	−0.002***	0.003***
	(3.913e − 04)	(3.415e − 04)
% Hispanic population	−0.027***	−0.019***
	(3.435e − 04)	(3.292e − 04)
% African-American population	0.004***	0.011***
	(2.645e − 04)	(2.698e − 04)
Median household income ($1,000s)	0.013***	0.015***
	(3.339e − 04)	(3.127e − 04)
% of population in poverty	0.001***	0.002***
	(3.356e − 04)	(3.160e − 04)
Constant	−1.141***	−2.134***
	(0.033)	(0.032)
R^2	0.132	0.215
Observations	7,385,305	7,385,305

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level. Clustered standard errors are in parentheses.

to A50 vendors, further suggesting that small vendors are not playing much of a role in facilitating participant access.

Multinomial Logit Analysis of Vendor Choices

Although table 3 provides insights into WIC participants' choices of vendor types as a function of food-desert status, we sought to look more deeply into this decision, as it lies at the heart of concerns about food access in food-desert areas and the importance of small vendors to providing access. To gauge participants' dependency on alternative program vendor types, a multinomial logit (MNL) model was estimated to study participants' shopping choices across each type of vendor—A50, small (1–5 registers), or large (6+ registers).

Table 7. Food Deserts and Vendor Choice: MNL Model

		Marginal Prob.	Std. Error	95% Confidence Interval	
FD	**A50**				
0		0.3884	0.0016	0.3853	0.3916
1		0.4539	0.0030	0.4480	0.4598
FD	**Small**				
0		0.1049	0.0009	0.1031	0.1066
1		0.1207	0.0024	0.1161	0.1254
FD	**Large**				
0		0.5067	0.0016	0.5035	0.5099
1		0.4254	0.0027	0.4200	0.4308

Motivating the MNL model is the idea that participants seek to maximize the utility associated with a WIC transaction; thus, the probability of visiting any vendor type is a function of characteristics that impact that utility, including both vendor and participant characteristics. A50 vendors, as noted, tend to be located in proximity to program participants (e.g., near WIC clinics) and to make purchasing easy and non-stressful, for example, by making authorized products easy to locate and emphasizing convenient checkout. Incentives that favor making purchases at larger vendors are a wide selection of WIC-eligible products and also favorable prices and selection of non-WIC products, providing participants the convenience of one-stop grocery shopping. However, a large vendor may not be located conveniently for a participant to access, and checkout may be time consuming and stressful.[26] In certain settings small vendors, which are often convenience-type stores, may also provide participants a favorable bundle of characteristics including location, easy checkout, and opportunity to combine WIC shopping with other purchases.

In the MNL model, a participant's choice of vendor type for each transaction was recorded as a discrete 0,1 value that was specified as a linear function of the same explanatory variables as included in model 1 from table 7. One of the response categories (A50 vendors, in our case) is chosen as a baseline or reference. The MNL model then estimates the log odds that a small (large) vendor, relative to an A50 vendor, is chosen by a participant to redeem a particular FI, as a function of the aforementioned explanatory variables.

The coefficients in log odds form are difficult to interpret, so we follow convention and present results of the estimation in table 7 in terms of marginal probabilities, focusing specifically on the food-desert variable. The 95% confidence intervals computed via the delta method are also presented. Holding all other explanatory variables at their means, the probability of a comparison participant shopping at an A50 vendor is 38.8%, while for a food-desert participant it is 45.4%. Food-desert participants are somewhat less likely to shop at large vendors than participants in the comparison group—42.5% versus 50.7%—and slightly more likely to shop at small vendors—12.1% versus 10.5%.

Although these results are comparable to the simple averages contained in table 3, the marginal probabilities control for the presence of the other explanatory variables, and some differences from the simple averages are apparent. Although treatment participants redeemed a slightly higher share of FIs at large vendors than Comparison 1 participants, the marginal probability of shopping at a large vendor is, *ceteris paribus*, less for a food-desert participant once other factors are included. Similarly, although food-desert participants redeemed a slightly lower percentage of transactions at small vendors than Comparison 1 participants, the marginal probabilities suggest that food-desert participants are slightly more likely to redeem at small vendors than their Comparison 1 counterparts. A50 vendors are important redemption options for both groups, but the marginal

[26] To make a purchase, the participant must group the purchases by food instrument, announce to the cashier that WIC food instruments are being used, and sign the food instrument vouchers after the cashier has recorded the purchase price. This process might be both time-consuming and stressful in a supermarket with long checkout lines.

probability of using an A50 vendor is about 7 percentage points higher for food-desert participants relative to Comparison 1.

Comparison Group 2

Here we present only a brief review of results when Comparison 2 is used in the analysis in place of Comparison 1. Full results for analysis with Comparison 2 are available from the authors. Comparison 2 participants traveled a slightly shorter average distance to shop, 3.06 miles versus 3.20 for Comparison 1. Food-desert treatment participants were slightly more likely to shop at vendors with 7+ registers than Comparison 2 participants, but Comparison 2 shoppers redeemed only 6.1% of transactions at small vendors, less than treatment or Comparison 1. Figure 2 comparisons regarding numbers of vendors patronized were nearly identical between Comparisons 1 and 2. Comparison 2 shoppers paid an average price of $18.16 per food instrument, less than the $18.49 average FI price paid in the treatment group and $18.73 paid in Comparison 1. Thus, although the average prices paid are closely comparable, the qualitative result that treatment shoppers paid less is not robust to choice of comparison group.

Conclusion

This analysis sheds light on issues of access to WIC Program benefits and for food access more generally in officially designated food-desert areas. By examining WIC Program transactions in the Greater Los Angeles area, this study has the advantages of a much larger sample size than prior food-desert studies and of being able to focus directly on a particularly vulnerable demographic, low-income women who are either pregnant or have infants or small children.

In general, we found limited differences in food access and food costs for WIC participants in food deserts relative to two comparison groups of WIC participants assigned to clinics well beyond the boundary of any food desert. Food-desert participants traveled on average 0.39 miles farther to shop (or 0.30–0.49 miles farther when controlling for other factors in the regression model) relative to the main comparison group. Food-desert participants redeemed nearly 88% of their food instruments outside of any food-desert area, affirming the limited shopping options in food deserts.

However, given their incremental travel distance, food-desert participants were able to access shopping opportunities and prices comparable to those available to comparison participants. In particular, food-desert participants were as likely on average to patronize vendors operating seven or more registers as comparison participants and were slightly less likely on average to patronize small, 1–4 register vendors. Marginal probabilities based on multinomial logit analysis differed somewhat from these average probabilities but confirmed the essential finding of little difference between the shopping behavior of food-desert and comparison participants. Also affirming this key point was evidence presented in figure 2 that propensities to visit multiple vendors (thereby indicating shopping options) were nearly identical between treatment and comparison groups.

Moreover, two comparisons of prices paid for the staple foods contained in the food instruments included in the study showed that food-desert participants paid closely comparable prices relative to comparison participants—slightly less on average than Comparison 1 and slightly more than Comparison 2—and that food actually purchased in a food-desert area (whether by treatment or comparison participants) did not cost more than food purchased beyond the boundaries of a food desert.

These results, along with the average participant travel distances of 3.20 and 3.59 miles for comparison and treatment groups, respectively, suggest greater shopping mobility among low-income residents in urban areas than prior studies such as Correll (2010) have posited. They further suggest that the 1.0-mile distance from a supermarket used in USDA food-desert definitions is rather

arbitrary and not consistent with the actual food-shopping practices of urban residents, whether or not they are located in official food deserts.

Regarding WIC Program policy implications specifically, the results suggest strongly that small, non-A50 vendors did not provide critical program access for the vast majority of food-desert participants in GLA. Most of the food-desert participants who did visit small vendors also visited A50 or large vendors. Only 1.35% of over 78,000 treatment participants in the GLA study area patronized a small, non-A50 vendor exclusively during the 24-month study period.

State WIC agencies thus might consider greater controls on the pricing practices of these vendors, similar to those in place nationally for A50 vendors. Because WIC operates with a fixed budgetary appropriation, savings from improved cost containment would enable the program to serve more participants. Although our results indicate that these vendors provided critical program access to only a small percentage of food-desert participants in the GLA area, WIC officials in California and elsewhere must weigh the downside of more stringent cost containment, which is reduced access if small vendors exit the program under more stringent price controls for those participants who patronize them exclusively, relative to the potential benefits.

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